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A systematic review of EBM (Evidence Based Medicine) and medical guidelines on the assessment of trauma-based spinal instabilities

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Diagnostic Procedure: X-ray stress test using end-range views: maximum flexion and maximum extension for the determination of segmental instability as a result of trauma.

Background
The purpose of this document is to expose the clinical indications, methodologies and validity of a specialty radiology study called end range X-ray stress test for the cervical or lumbar spine

The protocols are largely governed by Canadian and American Medical Associations and the American College of Radiology. Surgical indications for instabilities are guided by the American Medical Association Guidelines. The Financial Services Commission of Ontario (FSCO) fully endorses the Radiology Guidelines on spinal instability as described in this paper.

The studies referenced in this paper cover the protocols, reliability, validity and indications specific for the order to this test, indicated by spinal trauma. The use of geometric lines on x-ray is the required diagnostic procedure of choice for the determination of ligamentous injuries.

Protocols
Radiology Guidelines as governed by the AMA and the American College of Radiologists (ACR) are used in the Province of Ontario. These guidelines are fully endorsed by FSCO[1]. The guidelines state that spinal displacements must be categorized in one of 6 types:

1. Segmental Subluxations
2. Postural main motion and coupled motion
3. Snap-through buckling in the sagittal plane
4. Euler buckling in AP/PA view
5. Scoliosis
6. Static and dynamic segmental instability.

The ACR has published guidelines that support Family Physicians, Surgeons, and Neurosurgeons' use of routine spine x-ray.[2] These guides include x-ray procedures used to assess spinal trauma as well as determine what measurements on x-ray are considered to be deemed positive for spinal instability. The x-ray procedure required to evaluate spinal stability requires these two specialty views: end-range flexion and extension views. .[3 4]

Static and dynamic segment instability is defined as segmental displacements of specific spinal levels that are either at the limit of or past the limit for range of motion of the functional spinal unit. These are listed by the authors as being associated with significant ligamentous trauma. [4]

Furthermore, the Guidelines[1] state: '*we must emphatically reiterate that all 6 of the above structural subluxations require radiographic analysis for valid identification and quantification*.' The guides have compared the use of radiographic analysis to that of standard physical examination and surface spinal contour assessment, the later two options as being invalid and questionable. [5 6 7]

The Reed Group Neck Pain Guidelines (RGNPG) states that 'plain x-rays of the cervical spine may be indicated acutely if severe trauma has occurred and fracture or instability is suspected. X-rays are ordered if the symptoms have persisted for 30 days or more.' [8]

False Positive, Validity and the use of Geometric Lines for Instability Analysis Using X-ray

On the subject of false positive readings, Shaffer et al [9] states that high consistency and accuracy indices do not ensure acceptable false-positive and false-negative rates. Using roentgenograms (x-ray) as a basis for diagnosing instability often can lead to errors in classification. This is less so when observed translations are greater than 5mm on roentgenograms that are relatively clear, with little obliquity and concomitant motions are minimal.

Multiple published investigations have found correlation and predictive validity of the lateral cervical radiographic alignment to a variety of health related conditions [10 11 12] including:

1. Whiplash associated disorders
2. Segmental instability for angles 10 degrees or greater [13 14]
3. Radiculopathy

Besides visualizing the standard two radiographs for segmental instability, Ruth Jackson, MD was one of the first to draw some geometric lines for analysis. [15]

Current scientific thought is that a segmental translation of 3.5mm or more on a neutral lateral cervical or flexion/extension radiographs is evidence of ligaments instability. [4 16]

Cervical injury should be classified as 'major' if the following radiographic and/or CT criteria are present: displacement of more than 2mm in any plane, wide vertebral body in any plane, wide interspinous / interlaminar space, wide facet joints, disrupted posterior vertebral body line, wide disc space, vertebral bursts, locked or perched facets, hang man fracture of C2, dens fracture or type III occipital condyle fracture[17].

X-ray, Ligament Instability and Whiplash Trauma Patients

One of the first biomechanical studies designed to determine what ligaments are involved in segmental instability was performed by White et al in 1975.[18] White et al sectioned ligaments while loading the spines in flexion or extension. With all ligaments intact, they determined values of a maximum 2.7mm in segmental translation and 10.7 degrees in angular displacement. Any translation of 4.9mm or higher is near total failure of the cervical joints ie. Multiple ruptured ligaments.

In 1993, Dvorak et. al. [19]reported on a computer-aided method to determine cervical instability in 64 patients, divided into 3 groups, degenerative changes, radicular signs and whiplash trauma. Calculating segmental motion parameters, they stated that hyper-mobility in the upper and middle cervical levels for the trauma group and locations of the centers of motion were shifted in the anterior direction in the trauma group compared to healthy populations.

Reliability of Templating On Flexion-Extension Views

In 1989, Lind et. al. studied the range of motion of 70 healthy subjects in maximal flexion-extension and maximal lateral flexion.[20] Radiographs were analyzed on a digital tablet linked to a computer. The intra-observer error was (+/-)1.8 degrees.

Furthermore, in 1999, Schops et. al reported on a reliability study involving functional radiographic analysis of the cervical spine in flexion and extension as a screening method for segmental instability.[21] Five MDs measured angles of segmental mobility on 20 patients and 20 normal subjects. For segments C3/4, C4/5, C5/6 and C6/7, the correlation between 5 reviewers showed good to excellent results.

Diagnostic Indications For Radiology Study Involving Flexion-Extension

The flexion-extension stress films are useful in determining antero-listheses, hypo/hyper-mobility, evidence of instability. [22 23 24].

The usefulness of the 'dynamic study' is critical when one considers that a normal appearing neutral lateral cervical view does not exclude ligamentous injury . [25 26 27 28 29 30 31 32]

In fact, the determination of soft tissue and disco-ligamentous injuries using plain cervical spine radiographs (without flexion and extension) is poor. Additionally, it has been found that slight displacements or other subtle, yet significant findings from static lateral films which are indicative of more severe pathology, are often initially overlooked or so-called hidden. [15 18 24 25 27 33 34 35 36 37 38 39 40 41 42] This is why the use of stress films are encouraged especially after trauma such as whiplash [43].

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